COMIREX-D-33.4/1

6 August 1968

MEMORANDUM FOR: Committee on Imagery Requirements and Exploitation

SUBJECT: Summary of Non-Conventional Film Systems

REFERENCE: COMIREX-M-43, paragraphs 1-5

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Following a briefing given COMIREX by [redacted] OSA/DDS&T, on 18 July (see reference), the Chairman, COMIREX requested the Chairman, EXRAND to prepare a report on other dry processing or non-conventional film processing systems known to EXRAND. The attached represents a comparison of some relatively new types of film materials in various stages of development. Colonel Sowers emphasizes that although the survey EXRAND has compiled does present characteristics of divergent film materials that may now compete for a particular need, the study is by no means complete. The systems summarized reflect only major developments which EXRAND has been watching. There are other systems under development and when sufficient additional information is available it will be reported in a similar format to permit a continuing comparison. There is a wide market for new film systems and plenty of room for development of systems which could supplant or supplement conventional silver films.

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[redacted]
Executive Secretary
Committee on Imagery Requirements and Exploitation

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The Kodak BIMAT TRANSFER Process in Brief

Four basic components are needed for BIMAT TRANSFER processing: a Kodak BIMAT TRANSFER FILM, suitable processing chemicals, suitable handling equipment, and an exposed negative film.

The BIMAT TRANSFER FILM is soaked in the imbibant which is absorbed by the special gelatin layer on the Transfer Film. The BIMAT Transfer Film, treated to contain a predetermined amount of imbibant, is then laminated in intimate face contact with the exposed negative film for a suitable length of time. At the end of the processing time, the two films are separated. The negative has been developed and fixed in the process, and the BIMAT Transfer Film contains a positive image. Both films are damp (they feel slightly tacky to the touch); with suitable equipment, they can be completely dried. If kept dry, the images will have satisfactory stability for a few months. If image permanence for archival keeping is necessary, both films should be washed and dried, in the conventional manner, as soon as convenient.

The process follows the principles of diffusion transfer processing. When the exposed negative film is placed in intimate contact with the pre-soaked BIMAT TRANSFER FILM, the solution begins to diffuse into the emulsion of the negative film. Exposed negative grains begin to develop, and both unexposed and exposed negative grains begin to dissolve in the silver halide solvent. Some of the dissolved silver halide diffuses into the BIMAT TRANSFER FILM where it is reduced to silver on the nuclei there present and forms a positive image.

Summary of Advantages

The soaked web eliminates the problem of containing liquids. Processing equipment can be placed in any position such as in a maneuvering airplane without affecting processing. Automatic unattended processing is possible.

A positive image is produced for immediate use. A high-quality negative is produced. Fresh processing solution is used on all film areas, which insures consistent and reproducible results. Shelf life of the positive and negative can be archival if they are washed.

Shelf life of the materials before processing can be many months if the BIMAT FILM is kept dry, i.e., not imbibed, until ready to be used.

Summary of Disadvantages

Requirement for imbibing is cumbersome especially when compared to true dry processes. Although the positive and negative can be viewed within a few minutes of entering the processor, the surfaces are still tacky and, therefore, not suitable for normal photo interpretation. For longer life a conventional wash and drying are necessary.

Resolution of the positive is limited, approximately 50 lines/mm. This limitation is inherent because of the diffusion process that transfers the image from the negative to the positive. The negative has no resolution limitation caused by the BIMAT process.

Level of Development

BIMAT has been on the market for at least two years. Presumably large quantities could be available on relatively short notice. Kodak's reputation stands behind the quality control. Several companies have produced BIMAT equipment.

BIMAT/DESIMAT System

BIMAT Laminator

Work to solve the "tackiness" problem has been under way for some time. The first success was the development of a thin cover-sheet material which could be laminated to the BIMAT positive as it was delaminated from the negative. The clear material permanently covers the tacky surface and permits immediate handling of the film.

DESIMAT

The processed negative also could be cover sheeted. Unfortunately, the negative so treated cannot be used in a contact printer to produce duplicates of high quality. However, the problem has been solved by the development of DESIMAT tape and a simple piece of equipment called a DESIMAT Treater. In the Treater, the tacky negative is given a water dip and then is laminated briefly with the DESIMAT material, a chemically treated absorbent tape which acts as a blotter to remove the water (and some salts) from the BIMAT-processed film. This treatment leaves the film dry, clean, and immediately useable in printers, viewers, etc., just as are conventionally dried films.

DRIMAT

The system described so far provides a quick BIMAT positive and a clean negative. The complete Diffusion Transfer Processing System capable of providing unlimited quantities of duplicate copies was achieved with the development of DRIMAT film and the DRIAGARA Printer. DRIMAT film is a chemically imbibed processing film similar to BIMAT film. Unlike BIMAT film, however, DRIMAT film develops little or no density within itself. This film provides an ideal material for the rapid processing of exposed printed duplicates since the clear DRIMAT film provides the processing agents and simultaneously acts as a cover sheet.

DRIAGARA

The DRIAGARA Printer is a contact printer-processor, similar to a conventional Niagara printer, except that means are provided to laminate the exposed dupe film with DRIMAT film as the dupe film is accumulated on its take-up spindle. Thus, in a continuous manner, film is printed and processed on a single piece of equipment.

TRISPIN

There is one more piece of equipment, unofficially called the TRISPIN, which should be described. The BIMAT Laminator and the DESIMAT Treater are conceived as separate designs intended to turn out promptly and efficiently a viewable BIMAT positive and a printable original negative. The TRISPIN is a combination Laminator-Treater and is currently under design. This will permit early demonstration of feasibility in the field with simple equipment, since the TRISPIN can perform each of the laminating and delaminating functions of the System.

Advantages, Disadvantages, and Level of Development

The additions improve BIMAT's possibilities. A quick readout can be made on a non-tacky positive but the resolution is still limited. High resolution positives can be made from a non-tacky negative but the time had to be extended to three hours, and the mobility is reduced to one day air transportability to any field station. More equipment is needed but still less than for conventional silver. The logistic 'tail' is still relatively small compared to conventional silver processing especially for the water and electric power requirement. The development of the new additions still remain to be completed. Only mock-up processing equipment has been demonstrated in most cases, and prototypes are still in the proposal stage.

ITEK's GEL Processing

Itek recently announced a dry process for conventional silver films and papers. This was an internal development that they kept under wraps until 20 June 1968. They feel the development has advanced to a point at which it could use support for development for market quantities.

At first appearance, it looks like a version of BIMAT because of the application of a gel and then removal of a strip of film that contained the active ingredients. The basic process by which the developing agent is held and transferred to the silver film represents a different scientific principle. The active ingredients are held in place as a gel (a colloid) instead of being soaked into a base material. The gel consists of 98 percent active ingredients and 2 percent by weight gelling substance. The key to the process was getting a gel that behaved properly. Itek's patent position will be based on two particular gelling agents.

Advantages and Disadvantages

As with BIMAT the problem of containing liquids is eliminated. The processing can be accomplished in any position and automatically. Transport rates expected for a 70 mm portable processor are 5 to 20 feet/min. from dry to dry. The immediate output after the gel has been stripped off in the processor is almost dry (dryer than BIMAT and not tacky). Three or four minutes from a warm air blower is needed to completely dry the film. Compared to conventional silver processing the resolution is the same, but quality control is simplified and improved. As with BIMAT the logistical tail of power, water, personnel, etc. is reduced.

The gel needs further development Itek admits. Synerisis, "weeping" of the gel, is a limit on the shelf life because of the loss of the active fluids. Six-month shelf life at room temperature has been accomplished.

Level of Development

As the development stands now, gel processing is just a process for quick, dry development of conventional silver films and chips. Itek has not had the time or funds to produce equipment to sell a complete package. Production of gel is still on a relatively small batch basis. At the time of the first public presentations, 20 June 1968, no literature was available. For further information contact can be made directly [redacted] at Itek,

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ITEK RS

Itek RS film and paper materials represent a new photo process, not a new way to develop conventional silver films. It is not a dry process because the film must go through three separate baths and dried by hot air. The materials being marketed now require silver to form the image, although a true non-silver process is possible but not fully researched yet. Itek RS resolution is intrinsically diffraction limited because the "particle" size is the molecule size.

The latent image is formed by exposure of a non-silver photoconductor. Slow speeds limit the process to reproduction purposes. No unusual or strong light sources are needed. The exposed material must be processed immediately. Itek RS shows rapid deterioration of the sensitometric curve with length of time between exposure and development.

During processing, silver is deposited from a silver nitrate solution onto the unexposed areas. A silver savings is realized because silver is deposited only where the image is and not lost into a developing solution as with conventional silver. Because the non-silver photoconductor is not removed during processing, the photograph can be worked on, such as adding grid lines by a 2nd exposure. The retained photoconductor is a disadvantage, too, because of the fogging it causes upon repeated exposures and storage in lighted rooms. The addition of silver after exposure accounts for: excellent shelf stability, including stability to heat, gamma and x-radiation; and manufacture in actinic light, which greatly simplifies the development of equipment for large scale production and quality control, which is usually the most expensive part of development of other film materials.

Measured high contrast resolution of Itek RS coatings on high quality paper range to date from 400 to 600 l/mm. High and low contrast resolution of Itek RS film exceeds 600 and 228 lines/millimeter respectively. Excellent tonal response is maintained with the high resolution. The sensitometric curves, e.g., contrast, can be controlled but only in a gross fashion.

The Itek RS process allows a broad freedom in the selection of the sensor, the substrate, the method of binding the sensor to the substrate, and the chemical reaction to be used for image formation. The possibility exists for a truly non-silver process by depositing noble metal for image formation.

In one commercial embodiment, the process is used to produce fifteen times enlargements on paper from 35 millimeter film. After a two second exposure by the 500-watt tungsten projection lamp used as light source, the green sensitive Itek RS photographic paper is processed through a 9-inch straight path processor at the rate of 4.5 inches/second. Thus, the process of introducing image material, developing an image and stabilizing the system is being carried out at room temperature in two seconds in this case.

Film materials have been developed by Itek. They are now seeking funds and customers to develop production equipment for large quantities.

Dry Silver Film

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[redacted] Dry Silver is a new film material, not a new way to develop conventional silver films.

The Dry Silver process is like conventional silver in that the exposure changes the silver ions to metallic silver. Dyes have been tied to the silver in a complicated way with a resulting reduction in silver content of over 75 percent. Up to now the lower exposure speeds have limited Dry Silver to reproduction uses such as needed in the NPIC.

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[redacted] Dry Silver films are developed by controlled application of heat only. No water or any chemical, liquid or dry, is necessary for development. Heating can be accomplished with a platen such as in the specially developed fly-away kit or by hot air as in the high speed printer/processor. High quality prints or transparencies are ready for photo interpretation within a few minutes. The heating requires considerable electric power, but the other supply requirements are non-existent or minimal.

The quality of the image on Dry Silver films are comparable to high resolution conventional silver. It's as if the silver in dry silver film were acting as extremely small crystals. The resolution was gained at the expense of speed. Considerable control can be exercised over the sensitometric curve, too. Conventional silver films still have the advantage of a wider range of responses and applications, although Dry Silver resolution is higher.

A considerable amount of development effort has gone into Dry Silver over the last few years [redacted] As with most film materials, the engineering of equipment to produce large quantities of uniformly high quality film material is more exhausting than inventing a new photo emulsion formulation in the laboratory. Moderate size runs are now possible [redacted] Several equipment manufacturers are negotiating and planning to produce equipment to use Dry Silver materials.

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Free-Radical, Photopolymer, Diazo

Free-Radical, Photopolymer, and Diazo film emulsions represent three different approaches to producing the ideal film: non-silver, truly dry, diffraction limited resolution, and completely free of the need for supplies. The only logistics required are the film material itself, electric power, equipment for exposure and development, and people to operate the equipment.

Removal of all liquids, it should be noted, is a big step to automation and operation by quick-trained personnel. The liquids, whether used for activation, development, or washing/fixing, complicate the task of quality control and predictability of results. They require close watch by personnel whose skills have reached the level of an art.

In general, none can compare with conventional silver for acquisition speeds, although Free-Radical holds out even that possibility, eventually. The basic speed criteria is the ratio of image molecules per photon of exposing light. The Diazo ratio is one for one in UV light, which means it requires a very burdensome amount of electric power for exposure. The fundamental Diazo reaction will yield no escape from this. Photopolymers have attained a ratio of 100 to 1 by using the first photon as a catalyst. However, this results in an intrinsically unstable film material. Free-Radical materials have a one to one ratio during exposure to blue light. Red light development, however, multiplies the effect to thousands of image molecules for each original blue photon. There is no fundamental reason restraining Free-Radical materials from attaining acquisition speed ratios. In practice impurities and the lack of perfect light filters have kept speeds to reproduction uses.

Free-Radical materials represent an accidental discovery. Only in the last few years has a new branch of science come up to help explain what is happening. The chief researcher, Horizons Incorporated, still does not fully understand the basic reaction. Most of the characteristics required of an outstanding reproduction material such as a wide maximum and minimum density range, gamma latitude and control, blackness, shelf life, etc. have been demonstrated. Today's research is trying to optimize all these qualities in the same Free-Radical material at the same time. Pilot plant quantities are being produced and prototype exposing and processing equipment have been developed, but the work lacks a sophisticated, well funded research program.

Diazo materials have benefited from a score of years and large sums of research money. In the last couple of years basic break-throughs have made it a contender for reproduction of aerial photography instead of just a line copy, engineering drawing material. Diazo is now available with continuous tone capability. Diazo has become truly dry, too, needing only heat at a temperature of 260°F for development. No ammonia is given off in this latest version. As with regular diazo, the sensitometric curve is very resistant to control and/or change.

Photopolymers have not been in the forefront the last couple of years and most of the corporations developing them have abandoned the pursuit.